

ASSOCIATION OF TWO NEW *CORYPHASIA* SPECIES (ARANEAE, SALTICIDAE) WITH TANK-BROMELIADS IN SOUTHEASTERN BRAZIL: HABITATS AND PATTERNS OF HOST PLANT USE

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ABSTRACT. Two allopatric species of *Coryphasia* (Araneae: Salticidae), both described for the first time in this study, have been found associated with Bromeliaceae in distinct phytophysiognomies (e.g., inselbergs, highland forests and restingas) from southeastern Brazil. In this study, we investigated whether these salticids were associated specifically with bromeliads, and whether they used bromeliads of different species and sizes in distinct geographic regions. The *Coryphasia* species were rarely found outside bromeliads, occupied larger bromeliad species among those available, and were generally more frequent on bromeliads in open areas, such as inselbergs on mountain tops. The two *Coryphasia* species were observed submerging in phytotelmata, possibly as an anti-predatory behavior. The patterns of spatial and microspatial distribution and the submergence behavior of these species were similar to those of other bromeliad-dwelling salticids, which suggests a convergence among spiders that live on bromeliads.

Keywords: Animal-plant interactions, Bromeliaceae, spider, specific association, submergence behavior, phytotelmata

Plants of the family Bromeliaceae are almost exclusively neotropical and are frequently inhabited by a large variety of aquatic and terrestrial arthropods (Benzing 2000). Some spiders are specifically associated with bromeliads in South and Central America, and use these plants as foraging and mating sites, nurseries, and shelter against predation and climatic extremities (Barth et al. 1988a,b; Baurecht & Barth 1992; Dias et al. 2000; Rossa-Feres et al. 2000; Santos et al. 2002; Dias & Brescovit 2003, 2004; Romero & Vasconcellos-Neto 2004, 2005a,b,c; Romero 2006). All known species of neotropical wandering spiders of the genus *Cupiennius* (Ctenidae), for example, are closely associated with par-

ticular plants, especially the Bromeliaceae and Musaceae, on which they hide during the day and prey, mate, and molt during the night (Barth et al. 1988b). *Cupiennius salei* (Keyserling 1877) lives in close association with some bromeliad species (Barth & Seyfarth 1979; Barth et al. 1988b), and uses vibratory signals to communicate during courtship on the host plant (Barth et al. 1988a; Baurecht & Barth 1992). *Pachistopelma rufonigrum* Pocock 1901 (Theraphosidae) is also strictly associated with the tank-bromeliad *Hohenbergia ramageana* Mez. in northeastern Brazil, and probably uses these plants as a shelter against the high temperatures of the sandy soil and as nurseries (Dias et al. 2000; Santos et al. 2002; Dias & Brescovit 2003, 2004).

Recent studies have reported strict associations between jumping spiders and bromeliads (Rossa-Feres et al. 2000; Romero & Vasconcellos-Neto 2004, 2005a,b,c; Romero 2006). For instance, *Psecas chapoda* (Peck-

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ham & Peckham 1894) inhabits exclusively *Bromelia balansae* Mez., a terrestrial bromeliad that does not accumulate rain water, in several regions of Brazil, Paraguay and Bolivia (Rossa-Feres et al. 2000; Romero & Vasconcellos-Neto 2005a,b,c; Romero 2006). The entire life cycle of this species, including courtship behavior, mating, oviposition, and the population recruitment of immatures, occurs on this plant (Rossa-Feres et al. 2000; Romero & Vasconcellos-Neto 2005b). Whereas the leaves are used as foraging and mating sites, the base of the rosettes serves as a shelter and resting site, and the center of the bromeliads is used as a nursery (Romero & Vasconcellos-Neto 2005a,c). *Eustiromastix nativo* Santos & Romero 2004, and undescribed species of *Psecas* and *Uspachus* are also strictly associated with tank-bromeliads in southeastern and northeastern Brazil (Romero 2006), and probably use bromeliads as shelters against predators and high temperatures, as well as foraging and egg laying sites (Romero & Vasconcellos-Neto 2004). *Eustiromastix nativo* inhabits the larger bromeliads among those available, which suggests that this species may assess the physical state of its microhabitats (Romero & Vasconcellos-Neto 2004).

Two undescribed *Coryphasia* species have been found inhabiting some bromeliad species on mountain tops (inselbergs) and in highland forests and restingas (a sandy soil forest, common at the Brazilian coast) in distinct geographic regions of southeastern Brazil. These species are described and illustrated here for the first time, along with several details of their natural history. To understand the spider-plant relationships of these species, we addressed the following questions: 1) Are these *Coryphasia* species strictly associated with bromeliads? 2) Do these spiders occur more on bromeliads of larger size? and 3) Do these spiders inhabit all of the available bromeliad species with the same frequency? Additionally, anti-predatory behavior of these salticids are described.

METHODS

This study was done at four localities in southeastern Brazil: at a rocky, open site (inselberg) on a mountain top (elevation ~1900 m) and in an adjacent Atlantic rain forest near the town of Monte Verde (22°51'S, 46°20'W),

in Minas Gerais state, from August to October 2003, and in December 2004 and April 2005; on an inselberg of Sugar Loaf mountain (Pão de Açúcar, 22°57'S, 43°09'W), in Rio de Janeiro city, Rio de Janeiro state, from April to May 2004, and in a restinga (i.e., plant communities on sandy soil close to the shore, Lacerda et al. 1984) in the Ilha do Cardoso State Park (Parque Estadual da Ilha do Cardoso, 25°03'S, 47°53'W), an island located on the coast of São Paulo state, in April 2005. Additional observations were done in a tropical, semideciduous forest (elevation ~1000 m) in the Ecological Reserve of the Serra do Japi (23°11'S, 46°52'W), Jundiaí city, São Paulo state.

In Monte Verde, the bromeliads *Aechmea distichantha* Lem., *Nidularium innocentii* Lem. and *Vriesea bituminosa* Wawra were very common in the forest understory and were similar in leaf length and number of leaves (Table 1), although the first of these has a uniquely lithophytic habit, inhabits open areas of granitic rock in inselbergs, and has conspicuous spines along the leaf edges. In Rio de Janeiro, the bromeliad species found were *Alcantarea glaziouana* (Lemaire) Leme and *Neoregelia cruenta* (R.Graham) L.B.Smith, both of which inhabited only open areas of the granitic rocks on the inselberg (absent in forest), although only the latter had spines at their leaf edges. At Ilha do Cardoso, the bromeliad species found were *Quesnelia arvensis* (Vell.) Mez, *Aechmea nudicaulis* (L.) Griseb. and *Vriesea carinata* Wawra, and all occurred in shady environments (restinga understory); the first two species bore small spines and the latter had no spines along the leaf margins. In the Serra do Japi, the only terrestrial bromeliad encountered was *Bromelia antiacantha*; this species was the only one of all the bromeliads that did not form phytotelmata (i.e., tank that hold rain water).

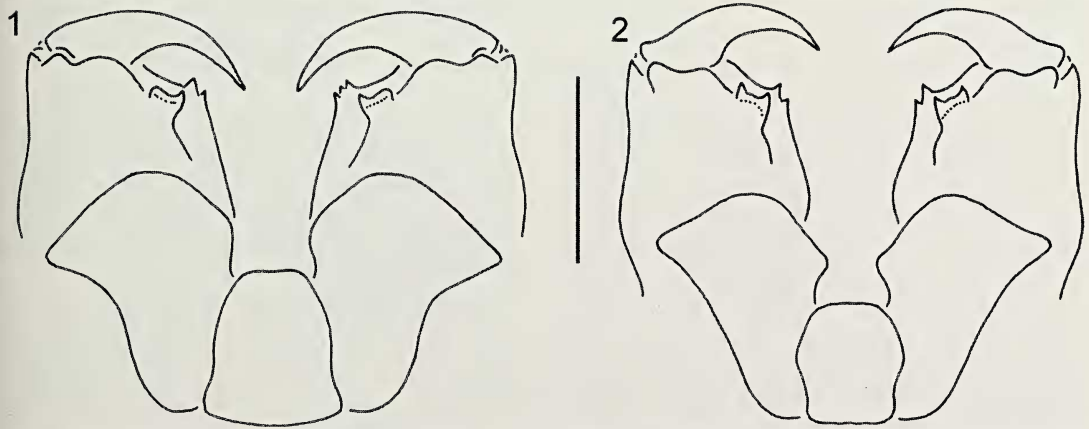
Two salticid species were collected on these bromeliad species, *Coryphasia monteverde*, a new species from Monte Verde and Serra do Japi, and *Coryphasia cardoso*, new species from Rio de Janeiro and Ilha do Cardoso. Both species are certainly members of the genus *Coryphasia*, which can be distinguished from other members of the subfamily Euphryinae by the presence of a bifid tooth on the posterior margin of the chelicerae, a lateral process on the endites (Figs. 1, 2), and the

Table 1.—Mean (± 1 SE in cm) of leaf length (LL), leaf base breadth (LB) and number of leaves (NL) for each bromeliad species at Monte Verde, Rio de Janeiro and Ilha do Cardoso. N = number of plants measured. Different letters indicate significant differences ($P < 0.05$, ANOVA/Tukey post hoc test for data from Monte Verde and Ilha do Cardoso, and Student t -test for data from Rio de Janeiro).

Bromeliad species	LL	LB	NL	N
Monte Verde				
<i>Aechmea distichantha</i>	29.76 $\pm$ 2.06 a	3.95 $\pm$ 0.23 a	23.35 $\pm$ 1.31 a	18
<i>Nidularium innocentii</i>	36.03 $\pm$ 1.54 a	3.62 $\pm$ 0.18 a	21.33 $\pm$ 1.16 a	16
<i>Vriesea bituminosa</i>	36.53 $\pm$ 3.55 a	7.47 $\pm$ 0.33 b	19.12 $\pm$ 1.33 a	17
Rio de Janeiro				
<i>Alcantarea glaziouana</i>	33.89 $\pm$ 0.90 a	10.0 $\pm$ 0.18 a	25.07 $\pm$ 1.12 a	81
<i>Neoregelia cruenta espinhos</i>	20.12 $\pm$ 1.01 b	7.04 $\pm$ 0.24 b	16.64 $\pm$ 0.93 b	25
Ilha do Cardoso				
<i>Vriesea carinata</i>	65.00 $\pm$ 4.86 a	6.80 $\pm$ 0.22 a	24.70 $\pm$ 1.53 a	10
<i>Quesnelia arvensis</i>	40.60 $\pm$ 2.00 b	6.02 $\pm$ 0.20 b	26.30 $\pm$ 2.22 a	10
<i>Aechmea nudicaulis</i>	44.40 $\pm$ 2.70 b	5.27 $\pm$ 0.18 c	6.80 $\pm$ 0.25 b	10

male palpus without apical sculpturing on the embolus (Edwards et al. 2005). So far this genus contains eight species, all described from Brazil (Platnick 2006). After comparing the material collected in this study with recent illustrations of all species of the genus (Galiano 1963; Bauab Vianna 1986; Rinaldi & Avelino 2000; Edwards et al. 2005), we concluded that both species were unknown to science, and have therefore described them here. The description format follows that of Santos & Romero (2004), with all of the measurements in mm. The material examined was deposited in the spider collection of the Instituto Butantan, São Paulo, Brazil (IBSP, curator A.D. Brescovit).

We investigated whether the *Coryphasia* spp. were strictly associated with bromeliads or whether they also occurred on other plants. For this, we inspected the leaves (underside and upper side) and stems of herbaceous plants and shrubs (non-bromeliads) with a total height of up to 1.7 m; the branches and trunks of taller plants were inspected at a height of up to 1.7 m. The inspections were done between 9:00 h and 16:00 h. Similar methods have been used in other studies (Romero & Vasconcellos-Neto 2004, 2005a). At Monte Verde, plants from the forest ($n = 633$) and from the mountain top ($n = 529$) were inspected along two random 150 m $\times$ 5 m transects (one per site). We also inspected



Figures 1–2.—*Coryphasia* spp., chelicerae, endites and labium, ventral view. 1. *C. monteverde* new species; 2. *C. cardoso* new species. Scale bars = 0.5 mm.

the non-bromeliaceous plants on the inselberg at Rio de Janeiro ($n = 500$) and in the restinga at Ilha do Cardoso ($n = 320$) along randomly located transects of $150 \text{ m} \times 5 \text{ m}$ and $70 \text{ m} \times 10 \text{ m}$, respectively (one per site).

To determine whether the *Coryphasia* spp. inhabited larger plants, as do other bromeliad-dwelling jumping spiders (Romero & Vasconcellos-Neto 2004, 2005a,b), we sampled the first 70 rosettes of *Ae. distichantha* found, 40 of them unoccupied and 30 occupied by *Coryphasia monteверde* on the mountain top at Monte Verde. The same was done for *C. cardoso* at Rio de Janeiro, using 81 rosettes of *A. glaziouana* (40 unoccupied and 41 occupied by this species). We did not evaluate the preference of *C. cardoso* for bromeliads of different sizes at Ilha do Cardoso. The size (surface area) of each rosette of *Ae. distichantha* was estimated as the product of the width (at the base) $\times$ length of a leaf from the median layer (node) multiplied by 0.5, since the leaves of this species have a roughly triangular shape. The surface area of *A. glaziouana* was estimated using the same procedure but, since the leaves of this bromeliad have a rectangular shape, the product of the length $\times$ width was not multiplied by 0.5. The leaf area of each rosette was multiplied by the total number of green leaves so as to obtain an approximation of the total plant surface area. Only the bromeliads *Ae. distichantha* and *A. glaziouana* were used in these analyses because they were the most abundant at Monte Verde and Rio de Janeiro, respectively. The distribution of the relative frequencies of the rosette size classes available and those occupied by *Coryphasia* spp. were compared using the G-test in a contingency table (Sokal & Rohlf 1995).

To determine which bromeliad species were inhabited most by *C. monteверde* at Monte Verde, we inspected the first 62 individuals of *Ae. distichantha*, 111 of *N. innocentii* and 60 of *V. bituminosa* that were found in the forest, in a plot of $150 \text{ m} \times 20 \text{ m}$, and the first 70 individuals of *Ae. distichantha* on the mountain top, in a plot of $50 \text{ m} \times 30 \text{ m}$, to allow comparison between habitats. We also determined which bromeliad species were used most by *C. cardoso* in Rio de Janeiro by inspecting the first 268 individuals of *A. glaziouana* and 88 individuals of *N. cruenta* available on the inselberg, in a plot of $150 \text{ m} \times 20 \text{ m}$. The use of bromeliad species by *C.*

cardoso at Ilha do Cardoso was assessed by inspecting 166 individuals of *Q. arvensis*, 48 individuals of *A. nudicaulis* and 55 individuals of *V. carinata* available in the restinga, along a $70 \text{ m} \times 10 \text{ m}$ transect. For each bromeliad inspected, we recorded the absence/presence of the spiders. Among the bromeliads from Monte Verde forest and Ilha do Cardoso, *Ae. distichantha*, *V. bituminosa*, *Q. arvensis* and *V. carinata* showed terrestrial and epiphytic habits, whereas *N. innocentii* and *A. nudicaulis* were apparently only terrestrial and epiphytic, respectively. However, we examined only bromeliads that occurred on the ground and epiphytes up to 1.5 m tall. The bromeliads from Rio de Janeiro were all ground-dwellers.

We compared the occupancy of the spiders on different plant species by using a G-test. To calculate an expected value for the observed number of plants of a given bromeliad species occupied by spiders, we multiplied the proportion of occurrence (abundance) of this bromeliad species by the total number of bromeliads occupied (of all bromeliad species). This procedure was used because of the variable abundance of plants of each bromeliad species. The results were expressed as the percentage of bromeliads occupied [(number of bromeliads occupied/total number of bromeliads) $\times$ 100]. The *P*-values for multiple comparisons of the frequency of spiders on different bromeliad species (at Monte Verde) were adjusted using the Bonferroni correction ($P = \alpha/n = 0.05/3 = 0.017$).

RESULTS

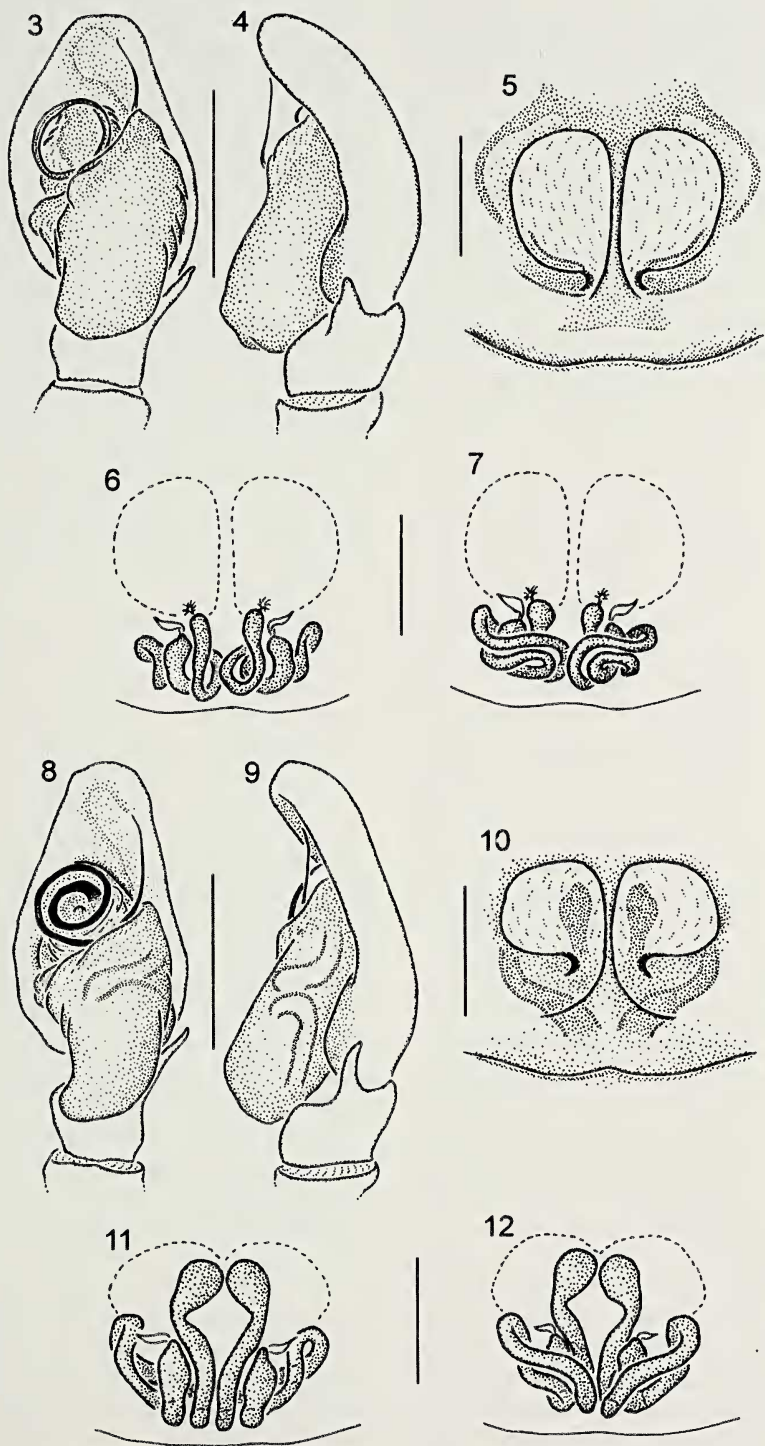
Coryphasia monteверde Santos & Romero new species Figs. 1, 3–7

Type material.—Male holotype from Monte Verde, state of Minas Gerais, Brazil, September 2003, G.Q. Romero coll., in IBSP 54541. Female paratype from the same locality, 9 August 2003, G.Q. Romero coll., in IBSP 54542.

Additional material examined.—BRAZIL: São Paulo: Jundiá, Serra do Japi, 26 June 2003, G.Q. Romero coll., 2♀ (IBSP 54543).

Etymology.—The species name is a noun in apposition taken from the type locality.

Diagnosis.—*Coryphasia monteверde* is



Figures 3–12.—*Coryphasia* spp. 3–7. *C. monteverde* new species: 3. Male palp, ventral view; 4. Male palp, lateral view; 5. Female epigynum, ventral view; 6. Female internal genitalia, dorsal view; 7. Female internal genitalia, ventral view. 8–12. *C. cardoso* new species: 8. Male palp, ventral view; 9. Male palp, lateral view; 10. Female epigynum, ventral view; 11. Female internal genitalia, dorsal view; 12. Female internal genitalia, ventral view. Scale bars = 0.5 mm.

similar to *C. melloleitaoi* Soares & Camargo 1948 and *C. fasciiventris* (Simon 1902) in their short posterior tegular lobe, which is the same width as the tegulum (Rinaldi & Avelino 2000: fig 14; Galiano 1963: figs. 5, 6). The males can be distinguished by the thin, flattened embolus, the large and anteriorly projected tegular ledge and the shorter retrolateral tibial apophysis (Figs. 3, 4). This species differs from *C. nigriventris* Mello-Leitão 1947 (Edwards et al. 2005: figs. 25–28) and *C. nuptialis* Bauab Vianna 1986 (figs. 12–14) by the embolus with a shorter, non-coiled apical portion. *Coryphasia castaneipedis* Mello-Leitão 1947 differs from all other species of the genus, including those described here, by the smaller embolus and the terminal lobe of tegulum pointed prolaterally (Edwards et al. 2005: fig. 21). *Coryphasia artemioi* Bauab Vianna 1986 (fig. 5) is probably misplaced in the genus, and presents palpal morphology consistent with the diagnosis of *Asaphobelis* Simon, 1902 as proposed by Edwards et al. (2005:23–24). Finally, *C. furcata* Simon 1902 and *C. albibarbis* Simon 1902 are similar, and differ from the remaining species of the genus, by the strongly curved terminal lobe of tegulum (Galiano 1963: figs. 6, 14). Females can be distinguished from all other species of the genus by the large lateral atria of the epigynum (Fig. 5) and the long seminal receptacle close to the spermathecae, with an apical star-shaped structure (Figs. 6, 7). This species also differs from the remaining species of the genus in the absence of anterior pockets in the epigynal atria (*C. fasciiventris*, Galiano 1963: fig. 7), and by the spermathecae located posteriorly to the epigynal atria, and not in their anterior half (*C. albibarbis*, Galiano 1963: fig. 16; *C. melloleitaoi*, Rinaldi & Avelino 2000: figs. 7, 8; *C. artemioi* and *C. nuptialis*, Bauab Vianna 1986: figs. 8, 16, respectively).

Description.—*Male (holotype)*: Carapace dark-brown, with black, pillose margins. Ocular area black, with long, semierect setae. Clypeus light brown, chelicerae red-brown, granulated, with apex of paturon and fangs orange. Labium and endites dusky, sternum yellow, covered with long hairs. Palps dusky. Legs I–II dusky, III–IV brown. Tarsus II–IV yellow. Legs I and II more robust than legs III and IV. Opisthosoma dusky, with a dorsal median yellow band with dark chevrons on the posterior half. Spinnerets gray, dusky lat-

erally. Total length 9.2. Carapace 4.2 long, 3.5 wide. Tibia I length 3.0, II 2.0, III 1.9, IV 2.1. Abdomen 5.0 long, 2.9 wide. Tegulum elliptic, with interior ducts barely visible.

Female (paratype): Carapace black, pillose, with a median red-brown band on anterior half of *pars thoracica*. Ocular area iridescent, with long hairs. Clypeus, chelicerae, labium and endites black, paturon granulated. Sternum red-brown, pillose, black in anterior lateral corners. Palps dark-brown. Leg I dark-brown, II–IV red-brown, coxae of all legs golden-yellow. Opisthosoma as in the male, without posterior chevrons. Spinnerets red-brown, darker laterally. Total length 10.4. Carapace 4.4 long, 3.6 wide. Tibia I length 2.1, II 1.6, III 1.8, IV 2.1. Abdomen 6.0 long, 3.8 wide. Internal genitalia with long, convoluted ducts, a pair of paramedian spermathecae with apical fertilization ducts and a pair of seminal receptacles (Figs. 6, 7).

Variation.—Females, total length 9.3–10.4, carapace width 3.3–3.6 ($n = 3$).

Distribution.—Known only from two mountain forest areas in southeastern Brazil.

Coryphasia cardoso Santos & Romero
new species
Figs. 2, 8–12

Type material.—Male holotype and two female paratypes from Parque Estadual da Ilha do Cardoso, Cananéia, state of São Paulo, Brazil, 16 April 2005, G.Q. Romero coll., respectively in IBSP 54538 and IBSP 54539.

Additional material examined.—BRAZIL: *Rio de Janeiro*: Rio de Janeiro, Sugar Loaf mountain (Pão de Açúcar), 30 December 2002, E. Wienkoski coll., 1♂ 2♀ 1 juv. (IBSP 24240).

Etymology.—The species name is a noun in apposition taken from the type locality.

Diagnosis.—*Coryphasia cardoso* males share with *C. albibarbis* Simon 1902 and *C. furcata* Simon 1902 a large, curved posterior tegular lobe (Galiano 1963: figs. 6, 14), but can be distinguished from both species by the longer embolus, which circles the base twice, the posterior tegular lobe which has a gentler curvature, and the ovoid apex of the cymbium (Fig. 8). Females are similar to *C. albibarbis* in their long seminal receptacle that is visible by transparency through the lateral atria of the epigynum (Galiano 1963: fig. 16), but differ from this species by the smaller atria (Fig. 10).

For more details on other species of the genus, see *C. monteverde* diagnosis.

Description.—*Male (holotype)*: Carapace dark-brown, pillose. *Pars thoracica* with a butterfly-shaped median red spot covered with white hairs. Ocular area black, with white hairs laterally and covered with long, semi-erect setae. Clypeus dusky, with a marginal fringe of white hairs. Chelicerae, labium and endites dark-brown, paturon granulated. Sternum gold-yellow, pillose, with marginal long hairs. Palps dark-brown. Leg I robust, dark-brown, II–IV red-brown, tarsus IV and apical half of metatarsus III–IV creamy. Opisthosoma creamy, with lateral dusky bands and posterior dusky chevrons. Sides black, venter creamy, with three longitudinal median dark stripes from epigastric furrow to spinnerets. Spinnerets creamy. Total length 6.4. Carapace 3.5 long, 2.8 wide. Tibia I length 1.8, II 1.6, III 1.6, IV 1.9. Abdomen 2.7 long, 1.8 wide. Tegulum long, gently curved prolaterally at the terminal lobe, with internal ducts visible by transparency (Figs. 8, 9).

Female (paratype): Color and hair covering as in the male, except for the following. Sternum red-brown. Coxae II red-brown, III–IV creamy. Total length 7.4. Carapace 3.5 long, 2.8 wide. Tibia I length 1.7, II 1.4, III 1.5, IV 2.0. Opisthosoma 4.0 long, 2.6 wide. Internal genitalia with lateral, convoluted copulatory ducts; paramedian spermathecae with apical fertilization ducts and a pair of median, long and apically spherical seminal receptacles (Figs. 11, 12).

Variation.—Females, total length 6.6–9.4, carapace width 2.8–3.3 ($n = 4$). Male from Rio de Janeiro (see below) with total length of 10.0 and carapace width of 3.8. Specimens from Rio de Janeiro are generally larger and darker than those from the type locality, and do not have the butterfly-shaped spot on the carapace.

Distribution.—Known only from two mountain forest and restinga areas in southeastern Brazil.

Association with bromeliads.—*Coryphasia* spp. did not inhabit non-bromeliad plants at Monte Verde and Ilha do Cardoso. However, in Rio de Janeiro, five individuals of *C. cardoso* were found on five non-bromeliad plants. In these cases, the plants occupied were shrubby and located up to 30 cm above thickets of the bromeliad *A. glaziouana*.

Coryphasia monteverde occurred non-randomly on individuals of *Ae. distichantha* of different sizes (surface area) at Monte Verde, with the highest frequency on larger bromeliads (contingency table, $G = 15.8$, $df = 5$, $P = 0.007$, Fig. 13). In contrast, in Rio de Janeiro the frequency of *C. cardoso* among individuals of *A. glaziouana* of varying size classes did not differ statistically (Fig. 13; contingency table, $G = 10.0$, $df = 5$, $P = 0.075$). The surface area of *A. glaziouana* was larger than that of *Ae. distichantha* (*A. glaziouana*: 9254 ± 670 cm², $n = 81$; *Ae. distichantha*: 902 ± 56 cm², $n = 70$; Mann-Whitney test, $U = 2524$, $P < 0.001$; see also Table 1).

In the forest at Monte Verde, *C. monteverde* used the available bromeliads non-randomly ($G = 24.14$, $df = 2$, $P < 0.001$, Fig. 14), and occurred at a higher frequency on *Ae. distichantha* compared to *N. innocentii* ($G = 24.13$, $df = 1$, $P < 0.001$) and on *V. bituminosa* relative to *N. innocentii* ($G = 7.70$, $df = 1$, $P = 0.005$). The frequency of *C. monteverde* between individuals of *Ae. distichantha* and of *V. bituminosa* did not differ statistically ($G = 3.65$, $df = 1$, $P = 0.056$). In this habitat, *V. bituminosa* was the largest bromeliad species (Table 1). This spider species was more common on *Ae. distichantha* from the mountain top (i.e., open area) than on individuals of this bromeliad species from forest ($G = 5.42$, $df = 1$, $P = 0.020$, Fig. 14), despite the smaller size of *Ae. distichantha* from the open area compared to that of forest specimens (mountain top: 902 ± 56 cm², $n = 70$; forest: 1446 ± 178 cm², $n = 17$; Mann-Whitney test, $U = 1022$, $P = 0.003$). In Rio de Janeiro, *C. cardoso* was more common on *A. glaziouana* than on *N. cruenta* ($G = 30.22$, $df = 1$, $P < 0.001$, Fig. 14). At this site, *A. glaziouana* was larger than *N. cruenta* (Table 1). At Ilha do Cardoso, the frequency of *C. cardoso* did not vary between the bromeliads *V. carinata* and *Q. arvensis* ($G = 2.33$, $df = 1$, $P = 0.127$), and this spider did not occur on *A. nudicaulis* (Fig. 14). The latter bromeliad was the smallest of those found at Ilha do Cardoso (Table 1). In Serra do Japi, we have monitored a population of *C. monteverde* established in a thicket of *B. antiacantha* for > 5 yr.

At Monte Verde, we found six and three egg sacs of *C. monteverde* on the leaves of *Ae. distichantha* in the forest and on the

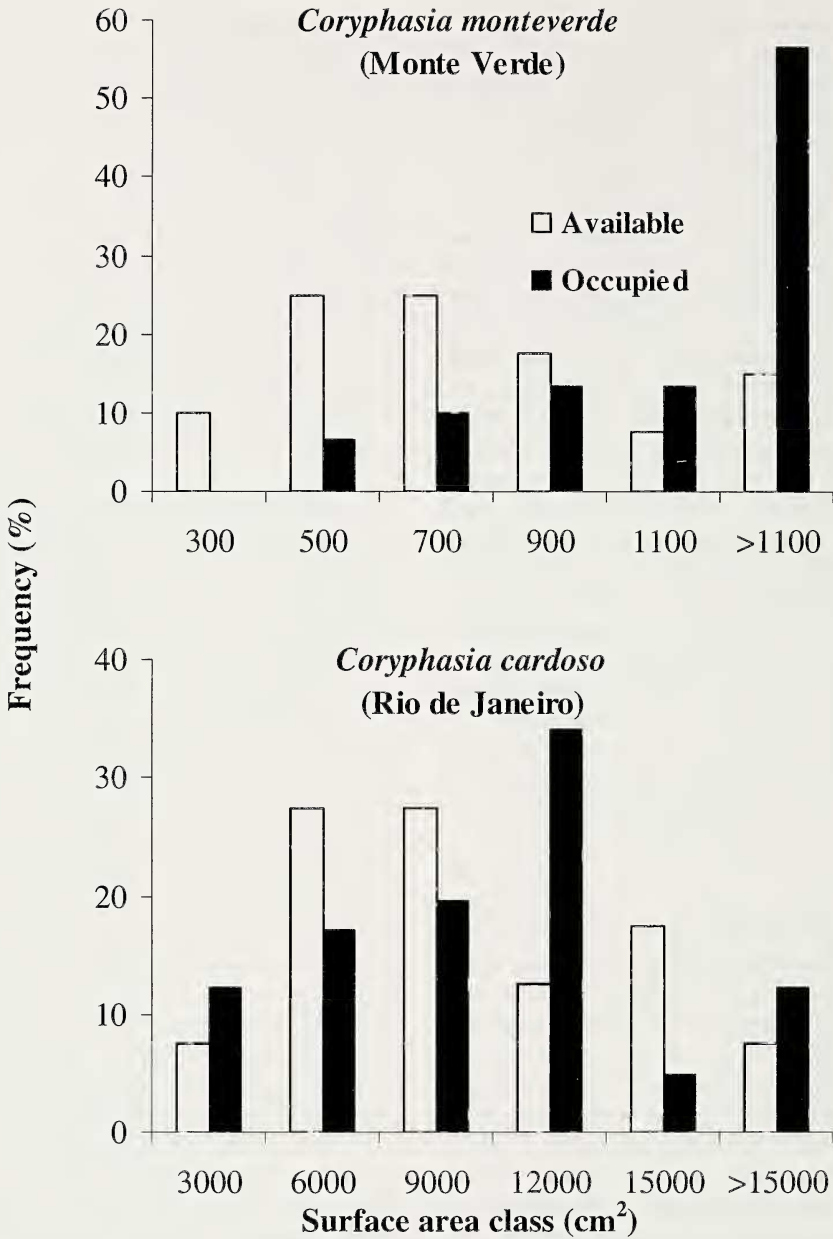


Figure 13.—Relative frequency of different size classes of *Aechmea distichantha* (from Monte Verde) and *Alcantarea glaziouana* (from Rio de Janeiro) occupied by *C. monteverde* ($n = 30$) and *C. cardoso* ($n = 41$) (black bars), respectively, compared to the total availability of these bromeliads (*A. distichantha*: $n = 70$; *A. glaziouana*: $n = 81$) (open bars).

mountain top, respectively. In Serra do Japi, we found one egg sac of this spider species on *B. antiacantha*. In Rio de Janeiro, we found five egg sacs of *C. cardoso* on *A. glaziouana*. No egg sacs were found on the bromeliads at Ilha do Cardoso.

Generally, when approached by an observer

trying to capture them, the two *Coryphasia* species climbed down a leaf to submerge in the water of tank bromeliads (e.g., *Ae. distichantha* and *A. glaziouana*). The spiders remained submerged for more than three minutes and were apparently surrounded by an air bubble. We have not observed this submer-

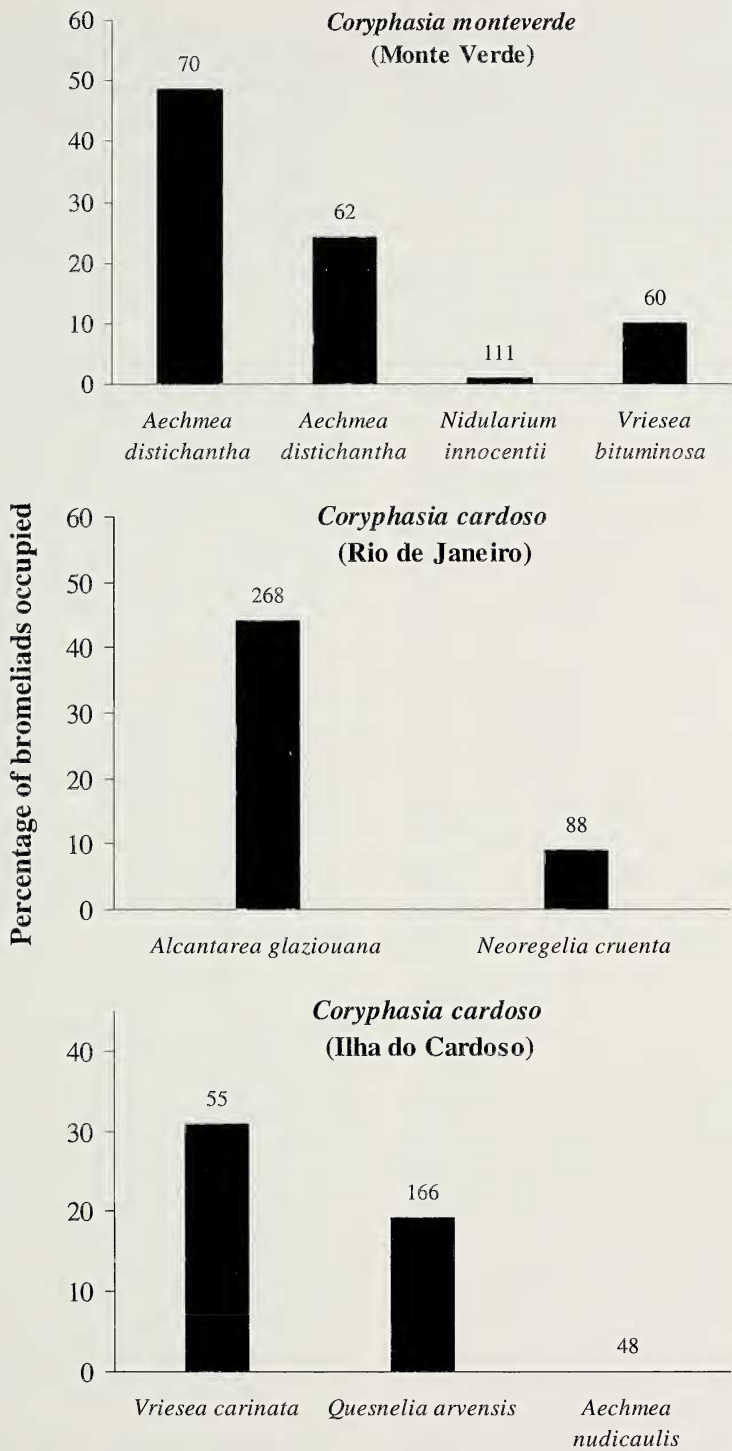


Figure 14.—Percentage of bromeliad species occupied by *C. monteverde* in the inselberg (first bar to the left) and forest (remaining three bars to the right) at Monte Verde, and by *C. cardoso* in the inselberg at Rio de Janeiro and restinga at Ilha do Cardoso. The number of plants inspected is indicated above the bars.

gence behavior in *C. cardoso* from Ilha do Cardoso. When on bromeliads that do not form phytotelmata (e.g., *B. antiacantha* from Serra do Japi), *C. monteverde* individuals quickly fled to peripheral leaves and buried themselves in the bromeliad rosette.

DISCUSSION

Our results indicate that *C. monteverde* and *C. cardoso* were specifically associated with bromeliads since they were rarely found on non-bromeliad plants. Moreover, these species inhabited bromeliads in different geographic regions, indicating a strong, specific relationship between these spiders and the Bromeliaceae. Bromeliads may be a suitable microhabitat for salticids because their leaves form a complex tridimensional architecture that allows adult spiders to forage and to shelter from predators (Romero & Vasconcellos-Neto 2005a,c). Moreover, plants in rosette shape may be good sites for spiders to lay eggs and as nurseries for spiderlings (Santos et al. 2002; Romero & Vasconcellos-Neto 2004, 2005a,c). In addition, since several bromeliad-dwelling spiders live in open areas (e.g., Santos et al. 2002; Dias & Brescovit 2003, 2004; Romero & Vasconcellos-Neto 2004, 2005a,b; Romero 2006), where the ground (e.g., sandy or rocky habitats) is generally hot during the day, bromeliads may provide shelter against high temperatures. We observed that the ground temperature on the inselberg at Monte Verde reached 50° C during the day (15:00 h), while among the bromeliad leaves and in the phytotelmata the temperature was 27° C and 22° C, respectively. Hence, the phytotelmata appear to function as a thermoregulatory mechanism for the bromeliads and indirectly provide a suitable microclimate for the spiders (see also Dias & Brescovit 2004).

Coryphasia monteverde inhabited the larger rosettes of *Ae. distichantha* at Monte Verde, which suggested that these spiders may actively select their microhabitats based on host plant size. Romero & Vasconcellos-Neto (2004) reported that another bromeliad-dwelling salticid, *E. nativo*, had a similar microspatial distribution on two bromeliad species, possibly because larger plants have a higher probability of being visited by insects as a result of their large surface area. However, in Rio de Janeiro, *C. cardoso* apparently did not discriminate the rosettes of *A. glaziouana* by

their size, perhaps because the detection of variation in rosette size among such large bromeliads (this species is much larger than *Ae. distichantha*) may be difficult or unnecessary for *C. cardoso*.

In the forest at Monte Verde, *C. monteverde* occurred at a higher frequency on *Ae. distichantha* and *V. bituminosa* than on *N. innocentii*, while in Rio de Janeiro, *C. cardoso* occurred at a higher frequency on *A. glaziouana* than on *N. cruenta*. *Vriesea bituminosa* and *A. glaziouana* were the largest bromeliads available in each region, and the spiders may have selected these plants because of their size. Although *Ae. distichantha* is a small bromeliad, it was the only one in the forest that had conspicuous spines at the edges of its leaves. These spines may provide protection against small vertebrates, as suggested by Romero & Vasconcellos-Neto (2005a,c) for other salticid-bromeliad systems. *Coryphasia cardoso* also inhabited the largest bromeliads, *V. carinata* and *Q. arvensis*. However, these spiders did not select plants with spines at their leaf margins in either of their areas of occurrence. Hence, this morphological trait in the plants from Rio de Janeiro (e.g., *N. cruenta*) and Ilha do Cardoso (e.g., *Q. arvensis*) may have no protective function for this *Coryphasia* species. Alternatively, this spider species may not select host plants that have spines on their leaf margins. *Coryphasia cardoso* did not occur on *A. nudicaulis* at Ilha do Cardoso. This bromeliad species, which was the smallest of the bromeliads available at this site, had leaves that were strongly clustered to form a tube-like rosette. This architecture may be unsuitable for active hunters such as Salticidae spiders that generally live and forage in tri-dimensional, open microhabitats (Romero & Vasconcellos-Neto 2004, 2005c). Alternatively, *C. cardoso* may avoid competition with and/or predation by females of the harvestman *Bourguyia albiornata* Mello-Leitão 1923, which frequently use *A. nudicaulis* as an oviposition site at Ilha do Cardoso (Machado & Oliveira 2002).

Coryphasia monteverde occurred more frequently on mountain top bromeliads, where the ground is rocky and trees are scarce, than on forest-dwelling rosettes. Romero & Vasconcellos-Neto (2005a) reported a similar dispersion pattern for *P. chapoda*, which was more common on rosettes of *B. balansae* from

grasslands (open areas) than on rosettes from forest understories. Romero & Vasconcellos-Neto (2005c) demonstrated that fallen dry leaves from forest trees blocked the base (center) of *B. balansae* and effectively prevented the spiders' access to shelter and rest sites. In the present study, several forest-dwelling bromeliads had many dry leaves from trees in their rosettes, and this may have prevented *C. monteverde* from taking shelter in the water source (phytotelmata).

The habit of the two *Coryphasia* spp. of submerging in the water of phytotelmata may be an anti-predator adaptation for living on bromeliads. Similar submergence behavior has been recorded for two other bromeliad-dwelling jumping spiders, *Eustiromastix natio* and *Psecas* sp. (Romero & Vasconcellos-Neto, unpublished data). These results suggest convergent behavior among these jumping spiders for living on tank-bromeliads.

In conclusion, *C. monteverde* and *C. cardoso* were specifically associated with bromeliads in different geographic regions and inhabited the larger bromeliads among those available. These spiders submerged in water of the bromeliad phytotelmata, as do other bromeliad-living jumping spiders, possibly as a protective adaptation for inhabiting tank bromeliads.

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LITERATURE CITED

- Barth, F.G. & E.A. Seyfarth. 1979. *Cupiennius salei* Keyserling (Araneae) in the highlands of central Guatemala. *Journal of Arachnology* 7:255–263.
- Barth, F.G., H. Bleckmann, J. Bohnenberger & E.A. Seyfarth. 1988a. Spiders of the genus *Cupiennius* Simon 1891 (Araneae, Ctenidae). II. On the vibratory environment of a wandering spider. *Oecologia* 77:194–201.
- Barth, F.G., E.A. Seyfarth, H. Bleckmann & W. Schüch. 1988b. Spiders of the genus *Cupiennius* Simon 1891 (Araneae, Ctenidae). I. Range distribution, dwelling plants, and climatic characteristics of the habitats. *Oecologia* 77:187–193.
- Bauab Vianna, M.J. 1986. Contribuição ao estudo dos Salticidae do Brasil, IV. Duas espécies novas de *Coryphasia* Simon, 1902 (Araneae). *Publicações Avulsas do Museu Nacional* 65:133–137.
- Baurecht, D. & F.G. Barth. 1992. Vibratory communication in spiders. I. Representation of male courtship signals by female vibration receptor. *Journal of Comparative Physiology A* 171:231–243.
- Benzing, D.H. 2000. *Bromeliaceae: Profile of an Adaptive Radiation*. Cambridge University Press, Cambridge, UK. 665 pp.
- Dias, S.C. & A.D. Brescovit. 2003. Notes on the behavior of *Pachistopelma rufonigrum* Pocock (Araneae, Theraphosidae, Aviculariinae). *Revista Brasileira de Zoologia* 20:13–17.
- Dias, S.C. & A.D. Brescovit. 2004. Microhabitat selection and co-occurrence of *Pachistopelma rufonigrum* Pocock (Araneae, Theraphosidae) and *Nothroctenus fuxico* sp. nov. (Araneae, Ctenidae) in tank bromeliads from Serra de Itabaiana, Sergipe, Brazil. *Revista Brasileira de Zoologia* 21:789–796.
- Dias, S.C., A.D. Brescovit, L.T. Santos & E.C.G. Couto. 2000. Aranhas em bromélias de duas restingas do estado de Sergipe, Brasil. *Biologia Geral e Experimental*, São Cristóvão 1:22–24.
- Edwards, G.B., I.M.P. Rinaldi & G.R.S. Ruiz. 2005. Revisão das espécies sul-americanas de aranhas da família Salticidae (Araneae) descritas por Mello-Leitão para o Brasil, com a resolução do gênero *Asaphobelis*. *Biota Neotropica* 5(2):1–31.
- Galiano, M.E. 1963. Las especies americanas de arañas de la familia Salticidae, descritas por Eugène Simon. *Redescripciones basadas en los ejemplares típicos*. *Physis* 23:273–470.
- Lacerda, L.D., D.S.D. Araujo, R. Cerqueira & B. Turcq. 1984. Restingas: origem, estrutura e processos. Niterói: CEUFF. 447 pp.
- Machado, G. & P.S. Oliveira. 2002. Maternal care in the neotropical harvestman *Bourguyia albiornata* (Arachnida: Opiliones): oviposition site selection and egg protection. *Behaviour* 139:1509–1524.
- Platnick, N.I. 2006. *The World Spider Catalog*, Ver-

- sion 7.0. American Museum of Natural History, New York. Online at <http://research.amnh.org/entomology/spiders/catalog/index.html>.
- Rinaldi, I.M.P. & M.F. Avelino. 2000. Descrição da fêmea e redescritção do macho de *Coryphasia melloleitaoi* Soares & Camargo, 1948 (Araneae, Salticidae). *Revista Brasileira de Entomologia* 44:79–83.
- Romero, G.Q. 2006. Geographic range, habitats and host plants of bromeliad-living jumping spiders (Salticidae). *Biotropica* 38:522–530.
- Romero, G.Q. & J. Vasconcellos-Neto. 2004. Spatial distribution patterns of jumping spiders associated with terrestrial bromeliads. *Biotropica* 36:596–601.
- Romero, G.Q. & J. Vasconcellos-Neto. 2005a. Spatial distribution and microhabitat preference of *Psecas chapoda* (Peckham & Peckham) (Araneae, Salticidae). *Journal of Arachnology* 33: 124–134.
- Romero, G.Q. & J. Vasconcellos-Neto. 2005b. Population dynamics, age structure and sex ratio of the bromeliad-dwelling jumping spider, *Psecas chapoda* (Salticidae). *Journal of Natural History* 39:153–163.
- Romero, G.Q. & J. Vasconcellos-Neto. 2005c. The effects of plant structure on the spatial and microspatial distribution of a bromeliad-living jumping spider (Salticidae). *Journal of Animal Ecology* 74:12–21.
- Rossa-Feres, D. de C., G.Q. Romero, E. Gonçalves-de-Freitas & R.J.F. Feres. 2000. Reproductive behavior and seasonal occurrence of *Psecas viridipurpureus* (Salticidae, Araneae). *Brazilian Journal of Biology* 60:221–228.
- Santos, R.L., M.G. Almeida & J.V. Nunes. 2002. Notes on the association of *Pachistopelma rufonigrum* Pocock 1901 (Theraphosidae) with phytotelm bromeliads in eastern Rio Grande do Norte State, NE-Brazil. *Journal of the Bromeliad Society* 52:122–124.
- Santos, A.J. & G.Q. Romero. 2004. A new bromeliad-dwelling jumping spider (Araneae, Salticidae) from Brazil. *Journal of Arachnology* 32: 188–190.
- Sokal, R.R. & F.J. Rohlf. 1995. *Biometry*. Third Edition. W.H. Freeman and Company, New York. 887 pp.

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